DOCUMENT RESUME

ED 108 872 SE 019 034

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TITLE An Investigation of the Teacher Behavior of Wait-Time During an Inquiry Science Lesson.
PUB DATE Mar 75
NOTE 40p.; Paper presented at the annual meeting of the National Association for Research in Science Teaching (48th, Los Angeles, California, March 1975)

EDRS PRICE MF-$0.76 HC-$1.95 PLUS POSTAGE
DESCRIPTORS Educational Research; Elementary School Science; Elementary Secondary Education; Instruction; *Interaction; Learning; *Nonverbal Learning; *Questioning Techniques; *Science Education; Secondary School Science; *Teacher Behavior
IDENTIFIERS Research Reports; *Wait Time

ABSTRACT

This study was designed to investigate the nonverbal teacher behavior of wait-time. Wait-time is the silence in a conversation following a teacher or student utterance. The primary purpose of the investigation was to document some of the behavioral and cognitive effects of wait-time and to delineate the interrelationships between the various forms of wait-time. The secondary purpose of the investigation was to study the expected inverse relationship between teacher scores on the Pupil Control Ideology Form and duration of natural teacher reaction Wait-Time. Fifty-one preservice teachers were used in this study; 31 were trained to use Teacher Reaction Wait-Times of about 0.5 seconds and 2.0 seconds with inner city elementary school children, while 20 teachers instructing junior high students were randomly assigned to use the shorter or longer wait-times while using an inquiry science lesson. The results indicate that teachers can be taught a technique whereby they can increase the amount of student-to-student interactions in small groups during science inquiry and can bring about an increase in the frequency with which students spontaneously make verbal contributions to the group. More robust science inquiry can be facilitated with the increased use of time-wait.
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# AN INVESTIGATION OF THE TEACHER BEHAVIOR OF WAIT-TIME DURING AN INQUIRY SCIENCE LESSON

by

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Discussion Paper
Concurrent Session Six
New York Room
3:45-5:15 p.m.
Tuesday, March 18, 1975

NARST
48th Annual Meeting
Los Angeles, California

SE 019 034

# BEHAVIOR OF WAIT-TIME DURING AN INQUIRY SCIENCE LESSON

by

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## Synopsis

This study was designed to investigate the non-verbal teacher behavior of wait-time used during an inquiry science lesson. Wait-time is the silence in a conversation following a teacher or student utterance. The investigation was designed to allow the investigator to attempt in a small group setting to (1) document some of the behavioral and cognitive effects of wait-time, (2) delineate whatever interrelationships might exist between the various types of wait-time, and (3) establish a relationship between wait-time and teacher attitudes toward pupil control. Specific forms of wait-time were defined as follows: (1) Teacher Reaction Wait-Time (TRWT)--silence after a student utterance and before a teacher utterance, (2) Student Reaction Wait-Time (SRWT)--silence after a teacher utterance and before a student utterance, (3) Teacher Initiated Wait-Time (TIWT)--silence between student utterances, (4) Student Initiated Wait-Time (SIWT)--silence between teacher utterances.

As wait-time is increased, the number of student-to-student interactions increases, students spontaneously initiate a greater number of statements, make fewer inferences,

and interrupt the previous speaker less frequently. Not only are the gross percentages of each of these variables different, but, as a multivariate test of difference between the established Wait and No-wait groups indicates, each variable, when adjusted for its interdependency upon the other variables, is an effect.

The factor analysis of six wait-time variables plus total interruptions allowed the indentification of two factors. "Student Controlled Silence," was the factor contributed to by the variables of duration of SRWT after teacher questions, SRWT after teacher utterances other than questions, and incidence of SIWT (the absence of a reply to a teacher question). "Teacher Controlled Silence," was the factor contributed to by the variables of duration of TIWT, duration of SIWT, incidence of TIWT (student initiated statements), and interruptions. The teacher seems to be responsible for the control of the duration or incidence of each of these variables in this second factor especially relative to the apparent origin of control for the other factor. The identification of these two factors, catagorizing the various wait-time variables, lends support to the decision to attribute control in the naming of each of the types of wait-time.

The estimated factor scores over each of the two groups, Wait and No-wait, for each of the control-of-silence factors identified were correlated with the different forms of TRWT for the Wait and No-wait groups. A correlation was found between the "Teacher Controlled Silence" factor and TRWT-substantive for the No-wait group. A similar correlation, which did not quite reach the criterion level of significance, was found for the Wait group.

## Background

Studies of silence in conversations have been made within the context of therapeutic counseling interviews and, also, within science classrooms. These two situations may seem too diverse to allow a comparison of techniques or results. However, both are helping situations, both depend heavily on open communication, and both require the trust of the person being helped. The biggest difference may be the degree to which the client can help himself. Both the counseling and classroom studies seem to bear on teacher behavior. These two areas of study would lead one to expect several outcomes of increased wait-time that are influential to the learning process.

### Products of wait-time

It might be supposed that if students and teacher have more silence in which to think during a discussion

there would be a greater continuity to the discussion. There may be less tendency for members of the group to go off on undesirable tangents or to unwittingly elaborate on incorrect contributions of other group members. Moriber (1971) argues in his study that student answers tended to be more often incorrect when short wait-times were employed. Instructors using short wait-times tended to quickly re-structure questions in the absence of a student reply, student initiated wait-time (SIWT). These restructured questions served only to confuse the students. Rowe (1973, p. 259) suggests that when longer wait-times are used, students make better connections between evidence and inferences. Within the studies of wait-time in counseling interviews, the level of congruence between interviewer's remarks and client's own beliefs is directly related to conversational silence in the interview (Matarazzo and Wiens 1972). The degree to which conversants can stay on the subject and only gradually shift their discussion of one topic to the discussion of another topic has been measured by employing Anderson's mean fundamental coefficient of commonality (Anderson 1971, p. 13). This coefficient is a quantity representing the occurrence of linking words (words in common) between successive statements uttered by speakers in a conversation, discussion, or presentation.

The amount of commonality in verbal interaction is proportional to the occurence of linking words between successive statements in a discourse sequence (Anderson 1970; Anderson 1972).

There are other products of wait-time which might be expected. Rowe (1973, p. 258) has found that student self-confidence increases by increasing the length of silence between a teacher statement and a student statement, student reaction wait-time (SRWT), and by increasing TRWT. Also, "slow" students make more contributions, students ask more questions, and "speculative thinking" increases. Garigliano (1972) found that increased SRWT led to fewer spontaneous student initiated utterances. This type of utterance would usually occur whenever there is a series of student statements. Each statement would be separated by an interval of silence, teacher initiated wait-time (TIWT). The incidence of TIWT would indicate the incidence of spontaneous student initiated utterances. Hence, Garigliano found SRWT to be inversely related to TIWT. He found greater incidence of students answering teachers with "I don't know" responses with increased SRWT. If increased wait-time does indeed give students more time to think or to build up self-confidence, then a more nearly equal distribution of participation by the student members of a small group might be expected. More student-to-student interactions might be expected in groups where teachers use longer wait-time. Long wait-time

groups would be expected to verbalize a greater number of inferences and suggestions for testing inferences. More questions would be expected from longer wait-time groups.

The process of wait-time

Teachers have been urged for many years to pause before calling upon a student to respond to a teacher question (SRWT). However, unless some strong set of classroom rules are rather strictly enforced, the teacher has no direct control over when a student speaks, particularly in small group activities and discussion groups. In fact, the presence of this sort of rule would tend to defeat the purpose of having students work in small groups, i.e., student-to-student interaction and spontaneous expression of ideas.

One might expect that if a teacher slows the pace, by increasing TRWT, the students may respond by increasing SRWT. In fact, each of the different types of wait-time may be interrelated. Matarazzo and Wiens (1972, p. 107) report a positive correlation between each partner's reaction wait-times in conversations. They also report that as one decreases his reaction wait-time, their conversational partner will tend to more often interrupt and visa versa (Matarazzo and Wiens 1972, p. 123). It is expected that a similar relation between TRWT and SRWT may exist in the classroom.

As teachers wait longer after a student response, the chances of that student or another student making an additional utterance, a student initiated utterance, would be increased. This would mean that TRWT would be related to the incidence of TIWT. If students become accustomed to waiting longer after a teacher utterance before replying, then the teacher might be expected to take longer to rephrase a question or statement in the absence of a student reply. Hence, TRWT would be related to SIWT. When teachers do wait longer after posing a question or making a statement, then the chances of a student reply may be increased. Stated another way, TRWT is inversely related to the incidence of SIWT. Finally, in order for one student utterance to be followed by another student utterance, the time interval between student utterances, TIWT, must be competitive with TRWT. In order to bring about an increase in the incidence of TIWT, the duration of TIWT must not be greater than the duration of TRWT.

A presage variable and wait-time

The influence of the power of the teacher to control the behavior of the pupils becomes obvious as one watches a teacher lead a group discussion. The attitude of

a teacher toward power may be related to his speech patterns. One of the factors which can be used to predict which person will emerge as a leader in a group is the amount of talking he does. (Hare 1962, p. 292; Cartwright and Zander 1953, p. 536; Carter, et al in Cartwright and Zander 1953, p. 558; Schmuck and Schmuck 1971, p. 37). Those who emerge as leaders of groups have been found to be articulate and perhaps even verbose. Teachers might be expected to follow this same pattern.

A teacher interested in maintaining power and control might be expected to try to talk more. In order to establish volubility, a teacher, or anyone, might be expected to get the edge on a conversation or discussion by decreasing the length of silence between a student and a teacher statement, teacher reaction wait-time (TRWT): the previous speaker might even be interrupted. A person's attitude toward maintaining power and control can be measured with the Pupil Control Ideology Form.

The Pupil Control Ideology (PCI) Form measures the degree which a teachers believes students should be controlled. (Willower, Eidell and Hoy 1973). Teachers who believe in a relatively large amount of control are called "custodial" and would typically receive relatively high scores on the

Pupil Control Ideology Form. These teachers view the school as an autocratic organization where both power and communication flow downward to the students. In contrast, teachers who believe in a relatively small amount of control are called "humanistic" and typically receive relatively low scores on the PCI Form. These teachers value democratic classroom climate with its open channels of two-way communication and increased pupil self-determination. If volubility, hence wait-time, and power aspirations are related, a negative correlation between teacher score on the PCI Form and TRWT would be expected. It might, also, be expected that teachers who score low on the PCI Form would be more easily trained in the use of wait-time.

Hypotheses

Hypotheses concerning the products of wait-time

** 1. The use of increased TRWT will increase the amount of student-to-student interaction.

*** 2. The use of increased TRWT will increase the incidence of inferences made by students.

* 3. The use of increased TRWT will increase the incidence of suggestions for testing inferences made by students.

* 4. The use of increased TRWT will increase the incidence of student questions.

* 5. The use of increased TRWT will tend to equalize the verbal involvement of each of the students.

* 6. The use of increased TRWT will increase Anderson's fundamental coefficient of commonality.

Hypotheses concerning the process of wait-time

* 1. The use of increased TRWT will decrease the incidence of SIWT.

** 2. The use of increased TRWT will increase the length of SIWT.

* 3. The use of increased TRWT will increase the length of SRWT.

** 4. The use of increased TRWT will increase the length of TIWT.

** 5. The use of increased TRWT will increase the difference, TRWT-TIWT.

** 6. The use of increased TRWT will increase the incidence of TIWT (increase the incidence of student initiated statements).

Hypothesis concerning a presage variable and wait-time

* 1. The length of TRWT used by more "humanistic" teachers, as defined by the Pupil Control Ideology Form, is longer than TRWT used by less "humanistic" teachers. (To be tested for

typical teacher wait-times before wait-time training takes place).

Procedures

Investigation of a presage variable and wait-time

During the first three week, field experience in the elementary school level science methods course at the University of Houston, the possible relationship between pupil control ideology and the natural use of wait-time by teachers was investigated. All of the 51 pre-service teachers enrolled in the science methods course who had chosen to teach in any of the grades three, four, five, or six were administered the Pupil Control Ideology Form at the close of the first of two field experiences. Also during the first field experience, the TRWTs used by each teacher were measured by timing with a stopwatch the appropriate silences in his or her lesson which had been recorded on videotape. The Elementary Science Study lesson, Mystery Powders (1967), was taught to small groups of students with each pre-service teacher instructing a group of three to five students. These students were enrolled in grades three through six in a low income area, inner city school. The advantage of using data collected in this situation is that

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* not supported; ** supported; *** significant decrease found

it is generalizable to many other schools. Only when this initial phase of the investigation was completed, were the teachers selected and trained for the investigation of the products and process of wait-time.

The selection and training of teachers occured during the second field experience of the science methods course. Both of the methods course instructors were asked to, cooperatively, identify those teachers who (1) appeared to be more concerned with the well being of the students rather than with their own personal needs, (2) successfully sustained an inquiry type science lesson, and (3) seemed genuinely interested in improving their own teaching skills. These rather subjective criteria were used to select the teachers in order to not disrupt the usual training procedures by administering more objective inventories.

The training program used to train teachers in the use of different lengths of wait-time consisted of initially providing the teachers with the definition of TRWT, practice to become accustomed to durations of one-half and three-seconds of wait-time, practice using specific lengths of wait-time in a classroom situation, and discussion of the problems of waiting in silence. Since the investigator was involved in the wait-time training, it was decided to train teachers to use both short and long wait-times and to

randomly assign the teacher to the No-wait and Wait groups just prior to when the instruction of the students was to begin. A further advantage of this procedure was that none of the teachers would feel that they were "special" or were being relegated to a control group.

To become accustomed to durations of one-half and three seconds of wait-time, each teacher read the part of a teacher from a script of a teacher-student discussion. Another teacher read the parts of the students. During the reading, the investigator timed the TRWT used and gave feedback to the teachers. Also, the teachers were able to time their wait-times directly by watching a large laboratory-type timer. All of the teachers read the part of the teacher in the script using one-half and three seconds of wait-time.

The teachers were next asked to practice using one-half or three seconds of wait-time at different times while instructing elementary students in an inquiry science lesson. The laboratory timer was again in view. Since each teacher alternatively taught along with a partner, the partner was able to signal the teacher when the proper amount of wait-time was being used. Many of the teachers reported difficulty in waiting for three full seconds particularly when students asked simple, nonsubstantive questions such as, "What is your name?". In discussions with the teachers the investigator

suggested waiting three full seconds only after substantive student utterances; utterances which dealt with the concepts being taught. Additionally, each teacher was given four small plastic cubes. These cubes were to be held in one hand, and when a student finished an utterance, the teacher was to pass a cube to his other hand and then the other three cubes were to follow at the rate of one per second. Only after all of the cubes had been transferred, was the teacher to reply to the student. In the actual study, the teachers who were to use short wait-times were, of course, given only one cube and were expected to reply as soon as the cube was transferred.

During the part of the study when data were collected, the students who were instructed were enrolled in the sixth and seventh grades in an inner-city junior high school. Twenty groups of four students each were instructed early in the school day, in the school cafeteria. All groups were taught the same lesson, an adaptation of the Elementary Science Study lesson, Mystery Powders (1967).

An introductory lesson was taught to the students on the day preceding the day data were collected. This was done in order to acclimate the students to the room, test the tape recorders used to tape record the lessons, and

attempt to provide an equal background for each of the student groups. The introductory lesson, taught by the investigator, required each group of students to make observations of each of the powders. Each student recorded his observations in a blank table catagorizing suggested observations. Very brief instructions were given to the students, wherein they were told to record their observations in the blank table. Each group worked at his task independently, without the need for discussion with the instructor.

On the following day, the sample of 20 teachers was randomly assigned to the Wait and No-wait groups and, also, randomly assigned to each of the student groups. The lesson, dealing with the identification of the powders in three different mixtures, was taught. Each group was again supplied with identical materials and the conditions of the first day of instruction were maintained. The lesson proceeded for thirty minutes and was tape recorded.

Typed transcrips were made of each of the group interactions. Each transcrip began with the first substantive student comment after the teacher gave directions and ended 10.00 minutes later. High fidelity audio equip-

ment was used to recover as much of the conversations as possible. Higher frequency sounds, which were inadvertantly recorded from other parts of the room, were selectively filtered out. Two tape recorders malfunctioned, leaving eighteen tapes to be analyzed. The various wait-times were measured with a stopwatch and the type of student utterance (question, inference, interruption, etc.) was recorded along the margin of the transcript. In order to calculate Anderson's mean fundamental coefficient of commonality, the pertinent verbal elements in each discourse unit were underlined. The first 50 utterances were used to compute the mean coefficient of commonality.

## Results

### A presage variable

The hypothesized relationship between pupil control ideology and wait-time was investigated during the first phase of the investigation by administering the PCI Form to 51 pre-service teachers before they received wait-time training. The mean score for the group was 43.6, somewhat lower than the reported mean score of about 58 obtained by practicing teachers (see Table 1). PCI Form scores were correlated with the duration of TRWT used by each of the

TABLE 1

Pupil Control Ideology Form scores and TRWT.

| | | Before wait-time training n=51 | Wait n=9 | No-wait n=9 |
|---|---|---|---|---|
| PCI Form score: | mean | 43.6 | 43.4 | 45.1 |
| | range | 33 | 11 | 22 |
| Correlation with TRWT-all (Kendall's $\tau$) | | .05 | .38 | -.14 |

teachers in the sample. Kendall's $\tau$ was computed for the ordinal data yielding a value of 0.05. Kendall's $\tau$ was also computed for the Wait and No-wait groups giving values of 0.38 and -0.14 respectively. The hypothesis suggesting an indirect relationship between PCI Form score and TRWT could not be supported at a level of significance of 0.05.

Products of wait-time

The hypothesized products of increased wait-time of: increased incidence of student-to-student interactions, student questions, student inferences, student suggestions for testing inferences, and student initiated statements were investigated. Each of the 1491 student utterances in the Wait group and the 1330 student utterances in the No-wait group were considered to be replicates of the experiment. Each of the utterances was rated dicotomously for each of the product variables. The means for each of the variables for the Wait and No-wait groups indicate the proportion of student utterances which have that variable present. The percentage of student utterances (See Table 2) for each of the product variables shows, in general, that students in the Wait group made 18% fewer inferences, made about the same number of suggestions for testing inferences,

TABLE 2

Percentage of the student responses occurring in each of the wait-time product variable catagories for the Wait and No-wait groups

| | Wait n=9 | | No-wait n=9 | |
|---|---|---|---|---|
| | mean | standard deviation | mean | standard deviation |
| Student-to-student interactions | 75% | 43 | 53 | 50 |
| Student inferences | 18 | 38 | 22 | 42 |
| Student suggestions to test inferences | 3 | 17 | 2 | 13 |
| Student questions | 14 | 35 | 12 | 32 |
| Student initiated statements (TIWT incidence) | 82 | 38 | 64 | 48 |
| Student replies to teacher directives | 14 | 35 | 21 | 41 |
| Student interruptions | 12 | 32 | 22 | 42 |

asked about the same number of questions, initiated 28% more statements, and verbally interacted with other students 41% more frequently than the students in the No-wait group. The tape recordings revealed what seemed to be an obviously smaller frequency (45% less) of interruptions by students in the Wait group, hence the inclusion of interruptions in the analysis of the data. There also seemed to be a tendency for students in the Wait group to less frequently (33% less) make statements in response to teacher directives. Therefore, the variables of student replies to teacher directives was included in the investigation.

Frequently, a single utterance fell into more than one of the variable classifications. The high percentage of student-to-student interactions and student initiated statements suggested that these variables were not independent of each of the other variables. In order to test the research hypotheses while taking into account a probable lack of independence between the variables a test of difference between the Wait and No-wait groups on the basis of the seven product variables, taken simultaneously, was performed.

A stepwise discriminant analysis program, BMD07M, from the Health Sciences Computing Facility, UCLA, was used to com-

pute sixth order residual variables for each of the seven wait-time product variables. Hence, each product variable was adjusted for its linear relation with the other six product variables to produce seven independent, although "abstract" variables. These residual variables are called "abstract" since the originally encoded variables were observed within the context of all the other variables. As the linear relationship of each of the other variables was taken into account in order to produce the residual variable, the context and, therefore, the meaning of the variable term changed. However, each residual variable can be supposed to be related to the original, observed variable.

Each of the hypotheses concerning the products of increased wait-time was tested at a level of significance of 0.05 by considering each of the hypotheses in the null form. A one-sided test criterion in conjunction with the alternative (research) hypotheses was used to compare each of the residual variable t-ratios with the critical value of t with ten degrees of freedom. Even though each student utterance was initially considered to be a replicate of the experiement in order to produce the residual variables, the tests of the hypotheses were made with a more conservative number of degrees of freedom. The number of degrees of freedom used corresponds to the number

of teacher-student groups minus two, minus one degree of freedom lost in each step taken to produce the sixth order residual variables. The hypotheses indicating increased incidence of student-to-student interactions and incidence of student initiated statements with increased TRWT were supported. The hypotheses indicating increased incidence of student questions, inferences, and suggestions for testing inferences were not supported. However, it was found that there was a decreased incidence of student inferences at a level of significance of 0.05. Also, the incidence of student statements which were replies to teacher directives and the incidence of student interruptions were found to be greater in the No-wait group at a level of significance of 0.05. (see Table 3).

The hypothesis suggesting more equal verbal involvement of each of the students was tested with the median test. The null hypothesis tested was that the distribution of the percentage of utterances made by each of the students over the teacher-student groups was identical in both Wait and No-wait groups. Table 4 shows the mean percentage of total student utterances made by each student when ranked from most to least talkative. The hypothesis of more equal involvement was not supported at a level of significance of 0.05.

TABLE 3

Sixth order residual variables for the Wait and No-wait groups

| Variable | Wait n=9 | No-wait n=9 | t |
|---|---|---|---|
| 1·2,3,4,5,6,7 | a* | b** | 7.80*** |
| 2·1,3,4,5,6,7 | b | a | 2.34*** |
| 3·1,2,4,5,6,7 | a | b | 1.40 |
| 4·1,2,3,5,6,7 | a | b | 1.71 |
| 5·1,2,3,4,6,7 | a | b | 6.95*** |
| 6·1,2,3,4,5,7 | a | b | 4.47*** |
| 7·1,2,3,4,5,6 | b | a | 7.21*** |

* a is the greater mean residual variable
** b is the lesser mean residual variable
*** $p < .05$, directional test is significant

Key:
1 incidence of student-to-student interaction
2 incidence of student inferences
3 incidence of student suggestions to test inferences
4 incidence of student questions
5 incidence of student initiated statements
6 incidence of student replies to teacher directives
7 incidence of student interruptions

TABLE 4

Mean percentage of total student utterances made by each student ranked from most to least talkative.

| | Wait n=9 | | No-wait n=9 | |
|---|---|---|---|---|
| | mean | range | mean | range |
| Student 1 | 35.0% | 12.6 | 35.9 | 12.3 |
| Student 2 | 27.6 | 2.8 | 26.7 | 5.8 |
| Student 3 | 22.0 | 10.1 | 21.7 | 10.7 |
| Student 4 | 15.4 | 10.7 | 15.7 | 16.2 |

TABLE 5

Percentage of the student responses occurring in each of the wait-time product variable catagories for the Wait and No-wait groups.

| | Wait n=9 | | No-wait n=9 | |
|---|---|---|---|---|
| | mean | range | mean | range |
| Anderson's mean coefficient of commonality | .15 | .09 | .18 | .16 |

The hypothesis suggesting an increase in the value of Anderson's mean fundamental coefficient of commonality was tested with the median test. Table 5 shows the means of the coefficient obtained for both the Wait and No-wait groups. The hypothesis that these indices are different was not supported using a one-sided test criterion at a level of significance of 0.05.

The unexpected result of greater incidence of inferences made by students in the No-wait group may have a simple explanation. One of the principle objectives of the lesson used was to have students make and test inferences. The students seemed to quickly understand what the objectives were. Inferences, then, may have been made for the purpose of pleasing the teacher and gaining rewards from the teacher.

The students achieved the objectives of testing their inferences mostly by independently trying out their ideas, often without completely verbalizing their thought processes. Hence, tests of inferences were made quite spontaneously by interacting with the materials provided rather than verbalizing about what tests to try. It was true that individual students debated their findings with the rest of the group, but usually these differences of opinion were solved by a practical experimental test. The reliance of the students on practical

tests may have lead to the finding that Anderson's mean fundamental coefficient of commonality could not be shown to be different for the Wait and No-wait groups.

Process of wait-time

Mean, modal, and median measures of central tendency were calculated for each of the various types of wait-time for each of the various types of wait-time for each teacher-student group. Since the distribution of the wait-time durations typically evidenced marked skewness to the right, means for each of the types of wait-times tended to reflect the presence of large but occasional durations. The modes for the wait-time variables tended to not discriminate between the wait-time values for the various subjects or variables, because of the large range of values and high density near the lower end of the dictribution. The median of the duration of the wait-times was selected to describe the wait-times used due to its stability, i.e., it is relatively uneffected by extreme values. The means of the Wait and No-wait groups for the medians of the various types of wait-times are displayed in Table 6. The incidence of SIWT, TIWT, and teacher and student interruptions are shown in Table 7. In general, it was found that the durations of wait-times in the Wait group were about twice the

TABLE 6

Mean durations of wait-time process variables using the medians of the wait-time for each teacher-student group for the Wait and No-wait groups

| | Wait n=9 | | No-wait n=9 | |
|---|---|---|---|---|
| | mean | standard deviation | mean | standard deviation |
| TRWT-substantive | 1.77 sec | 1.34 | .85 | .28 |
| TRWT-other | 1.93 | 1.52 | .94 | .41 |
| SRWT-after teacher question | 1.19 | .51 | .60 | .22 |
| SRWT-other | 1.83 | 1.29 | .96 | .34 |
| TIWT | 1.33 | .44 | 1.05 | .45 |
| SIWT | 3.38 | 1.76 | 2.66 | 1.47 |

TABLE 7

Incidence of wait-time process variables for the Wait and No-wait groups

| | Wait n=9 | | No-wait n=9 | |
|---|---|---|---|---|
| | median of incidence | range | median of incidence | range |
| TIWT | 109 | 163 | 95 | 119 |
| SIWT | 1 | 3 | 3 | 16 |
| Teacher interruptions | 2 | 14 | 9 | 17 |
| Student interruptions | 21 | 53 | 33 | 70 |

durations of wait-times in the No-wait group. The independent variable, TRWT, had a mean value of less than one second. TRWT was broken into the two subcategories of TRWT-substantive and TRWT-other. Both of these quantities were used to allow greater insight into the use of TRWT. SRWT was subdivided into SRWT-after teacher questions and SRWT-other. This division was done to allow easy comparisons with other studies of wait-time.

Although only TRWT was manipulated in the investigation, it was suspected that if any of the types of wait-time responded to a manipulation of TRWT, they might also respond to changes in the duration of any of the other types of wait-time. It was suspected that the various types of wait-time were not independent of each other. In order to accomodate dependence among the various types of wait-time in comparing the Wait and No-wait groups, and furthermore, explore the idea that some types of wait-time are teacher controlled whereas others are student controlled, a factor analysis of the data was performed.

The data consisted of seven variables, including: duration of SRWT-after teacher questions, duration of SRWT-other, duration of TIWT, duration of SIWT, incidence of interruptions (total), incidence of TIWT, and incidence of SIWT. The last three incidence variables were rescaled by dictomizing each variable about its median. A principal components analysis (Harmon 1967) followed by rotation to the usual varimax criteria

(Kaiser 1958) was achieved using a Madison Academic Computing Center program, Factor2 (see Table 8).

Two factors were identified. On the first factor the variables of duration of TIWT, duration of SIWT, incidence of interruptions, and incidence of TIWT loaded univocally. This factor was named "Teacher Controlled Silence". On the other factor the variables of duration of SRWT-after teacher questions, duration of SRWT-other, and incidence of SIWT loaded univocally. This second factor was called "Student Controlled Silence". The estimated factor scores (Thurstone 1935) over each of the two groups, Wait and No-wait, for each of the two factors identified were correlated with TRWT for each group. Table 9 shows the Spearman rank-order correlation coefficients for the correlations between each of the two forms of TRWT and each of the control-of-silence factors for both the Wait and No-wait groups. TRWT-substantive for the No-wait groups was found to be positively correlated with the "Teacher Controlled Silence" factor with the Spearman rank-order correlation coefficient of 0.68 at a level of significance of 0.05. It can therefore be stated that TRWT-substantive in the No-wait group is directly related with duration of TIWT and, also, duration of SIWT. Furthermore, TRWT-substantive is indirectly related to incidence of interruptions.

TABLE 8

Factor leadings for wait-time process variables
(principal components with varimax rotation procedure)
n=18*

| | "Teacher Controlled Silence" | "Student Controlled Silence" | $h^2$ |
|---|---|---|---|
| SRWT-after teacher question duration | -.038 | .866 | .751 |
| SRWT-other duration | .475 | .683 | .692 |
| TIWT duration | .882 | .111 | .790 |
| SIWT duration | .783 | -.170 | .642 |
| Interruptions total incidence | -.819 | -.248 | .732 |
| TIWT incidence | -.749 | .254 | .626 |
| SIWT incidence | .192 | -.742 | .588 |
| % Total variation | 41.2 | 27.6 | 68.9 |

* $\sigma_b = 0.258$

TABLE 9

Spearman rank-order coefficients between TRWT and control-of-silence factors

| | "Teacher Controlled Silence" factor | | "Student Controlled Silence" factor | |
|---|---|---|---|---|
| | Wait n=9 | No-wait n=9 | Wait n=9 | No-wait n=9 |
| TRWT substantive | .60 | .68* | -.10 | -.38 |
| TRWT other | -.03 | .42 | -.06 | .28 |

*p< .05

The negative sign of the factor loading for the variable of incidence of TIWT suggests that incidence of TIWT is inversely related to the TRWT-substantive variable. However, this is not so. The Wait group showed a 28% greater incidence of the variable student initiated statements which was originally defined in terms of incidence of TIWT. Also, the test of difference between the Wait and No-wait groups on the basis of the seven product variables, taken simultaneously, showed the incidence of student initiated statements (incidence of TIWT) to be greater in the Wait group as compared to the No-wait group at a level of significance of 0.05. The negative factor loading for incidence of TIWT came about as a result of merging the Wait group with its severly restricted range on the incidence of TIWT variable, with the No-wait group, in which an extended range of the variable operated, for factor-analytic purposes. The merged groups consequently showed a relationship between incidence of TIWT and TRWT indicative of the non-restricted range of the No-wait group. This situation does not exist for any of the other variables.

The hypothesis suggesting an increased difference, TRWT-TIWT, for increased TRWT was tested. The difference, TRWT-TIWT, for the various forms of TRWT was calculated for the Wait and No-wait groups. (See Table 10). The No-wait group was charac-

TABLE 10

Mean of the difference between TRWT and TIWT (TRWT-TRWT)

| | Wait n=9 | | No-wait n=9 | |
|---|---|---|---|---|
| | mean | standard deviation | mean | standard deviation |
| TRWT-substantive minus TIWT | .44 sec | .087 | -.20 | 1.08 |

terized by a negative value of about -0.2 seconds while the Wait group had a positive value of about 0.4 seconds. The negative value for the No-wait group indicates that entrance into the conversation often could not be accomplished without interrupting the previous speaker. A difference in the value (TRWT-TIWT) across the two groups was found at a level of significance of 0.05 using the test for differences between means and a one-sided test criterion.

Implications

There are several implications of this study for science teacher education. Science teachers can be taught a technique whereby they can increase the amount of student-to-student

interactions in small groups, at least for students typical of this study. When the teacher is the leader of a small group, student-to-student interactions can be facilitated by the teacher by employing longer TRWTs after student statements. Also, by using longer TRWTs a teacher can bring about an increase in the frequency with which students spontaneously make verbal contributions to the group.

This study gives evidence indicating that the length of time a teacher should wait during a TRWT is determined by the length of time students wait before speaking following a previous student statement. If students normally make verbal contributions quickly after a previous student statement, then the teacher can use relatively short TRWTs. However, if students do not quickly made additional contributions, then the teacher will have to use even longer TRWTs in order to out wait the students.

Interruptions and wait-time and hence the effects of wait-time are related. Short TRWTs bring about more interruptions. Teachers could be trained to notice the number of interruptions which occur in a small group discussion. The number of interruptions could then indicate to the teacher the appropriateness of the wait-times being employed.

Teachers are often told to pause after asking a question before repeating or rephrasing the question. This pause

supposedly gives the students time to think about the question. If a teacher is trained to use longer TRWT, then the teacher will automatically wait longer after asking a question or making a comment before speaking again.

The identification of two control-of-silence factors shows that there are some silences in a small group discussion which can be controlled by the teacher. Teachers have control of the silences after student statements and between teacher statements. However, the silence after a teacher statement or question is controlled by the students. It is, therefore, not practical to tell a teacher to pause before a student answers the teacher's question. If such a pause is desired, then it is the students who must be trained to pause.

The study shows that by manipulating one element of silence in a discussion an investigator can bring about charges in other speech pattern characteristics. An investigator can effectively use the specific wait-time of TRWT as a relatively easily managed independent variable. In fact, TRWT can be selectively used only after substantive student statements to produce effects without introducing an undesirable artificiality to the nature of a conversation.

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